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Majoring in Tactics, Naval Postgraduate School

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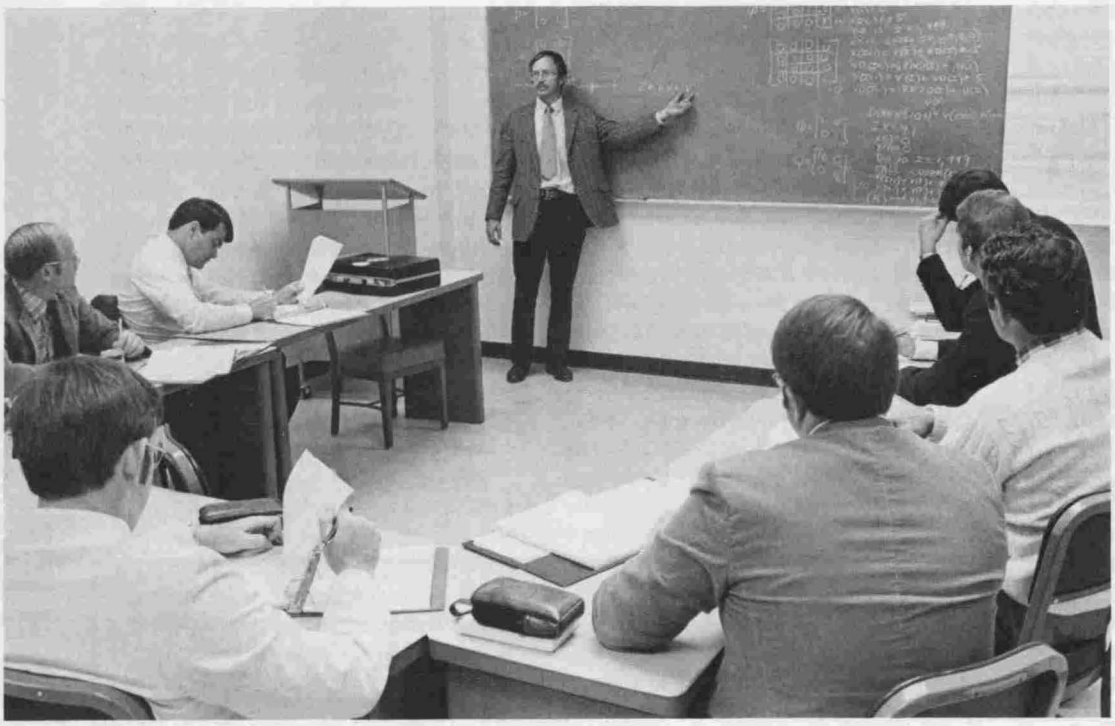
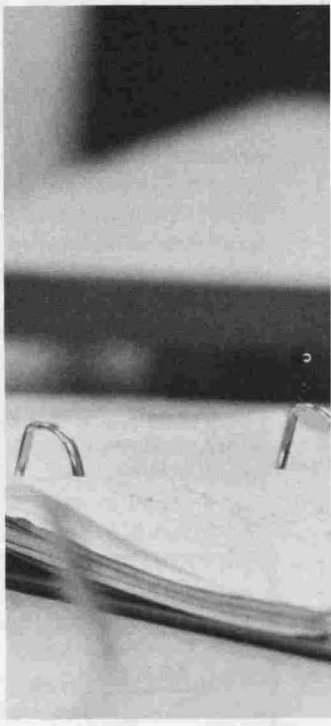
Majoring in Tactics– Naval Postgraduate School

Story by CAPT Wayne Hughes, Jr., Naval Postgraduate School
Photos by JO2 John H. Scott, Naval Postgraduate School





Among the quieter changes underway in support of the CNO's initiative to improve fleet tactical proficiency have been plans to modify the operations analysis curriculum at the Naval Postgraduate School (NPS). A pilot curriculum is being taught to the class that entered in October 1980 and will graduate in September 1982.

For perspective, I should point out that the spawning ground of modern operations analysis was the aerial Battle of Britain in World War II. Physicists had teamed with other British scientists to get their rudimentary new radar system into active operation as an early warning and fighter control system against the Nazi bombing campaign. It became evident that technological and operational considerations for the effective tactical employment of RAF fighter-intercepters were inextricably intertwined. The scientists who worked with the fighter command had given birth to the notion that scientific methods could be applied to combat. *(This is the conventional wisdom. I am prepared to defend the proposition that the work done in the Italian Revista Marittima around the turn of the Century constitutes some of the best operations analysis ever done. See* Fundamentals of Naval Tactics *by Lt Romeo Bernotti, IN, translated and published by the US Naval Institute in 1912. Both the proposition and the tactics are irrelevant today. The noteworthy point is that the mathematical models in it were developed by naval officers. Besides, it's great fun to read the book. It will also lend weight to the argument that the maneuvering board, which had then not yet been invented, was the single greatest advance ever made in tactical decision aids.)*

On this side of the Atlantic, at the end of World War II, the best known application of operations analysis was by the U.S. Navy's civilian scientist team who helped win the Battle of the Atlantic and became the Operations Evaluation Group (OEG). *(The First Navy civilian scientist operations evaluation group was convened by the Secretary of the Navy in World War I and was headed by Thomas Alva Edison,*

▲◀Professor Alan R. Washburn teaches a group of anti-submarine warfare students a class in combat models and weapons effectiveness.

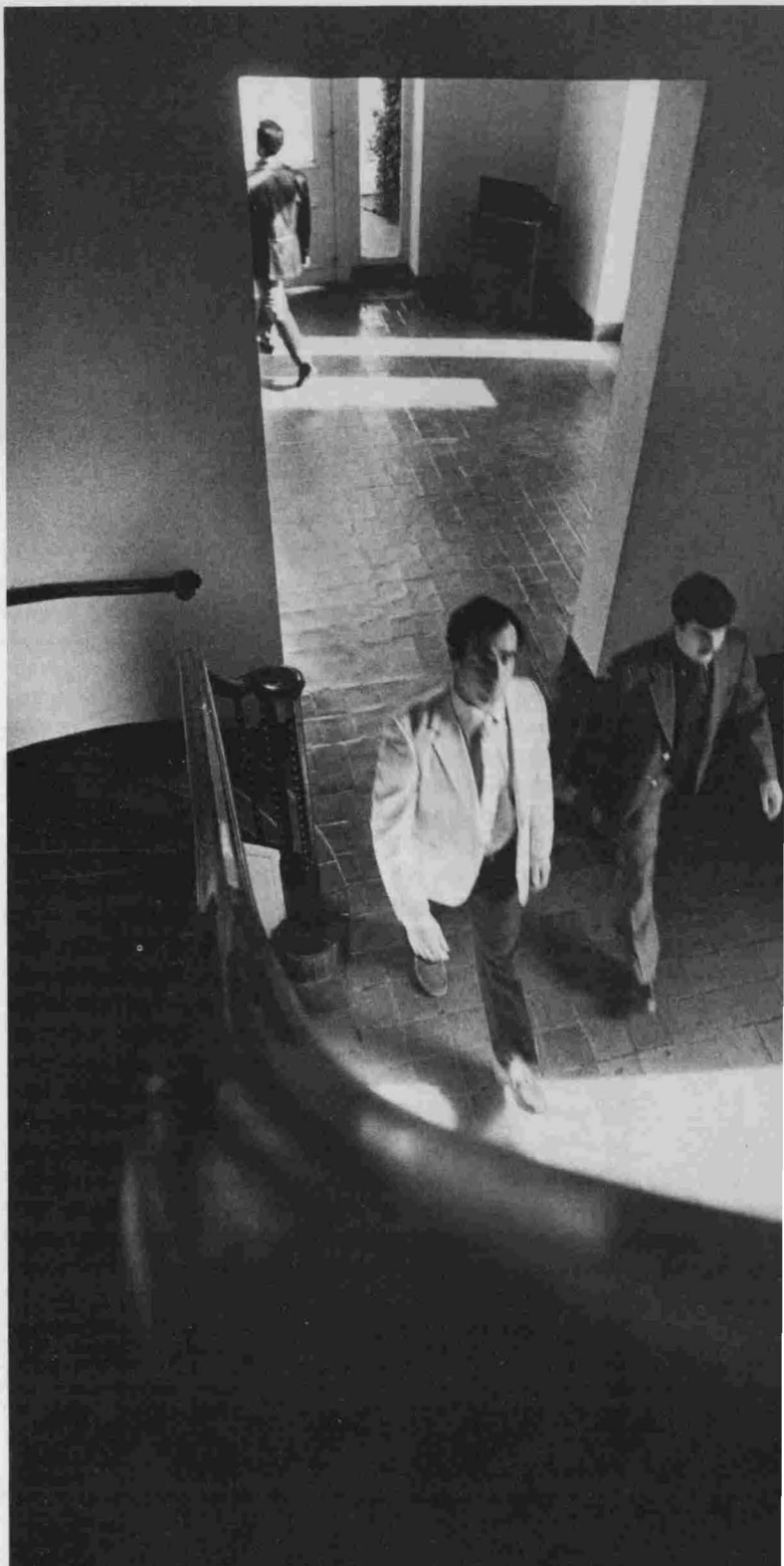
the inventor of the electric light bulb, phonograph, etc. [See Surface Warfare *Magazine, March 1978, page 2, "Searching for Superior Tactics".])* It was their analysis, as they worked side-by-side with TENTH Fleet officers, that determined the size and shape of World War II convoys and the stations and tactical employment of the convoy's surface and air escorts. The old "Bent Line Screens" to combat diesel submarines were their creations.

The U.S. Navy had been quick to perceive the value of operations analysis and saw the need to continue to foster the capability. After World War II, the various subgroups of operations analysis were consolidated into the Operations Evaluation Group (OEG) and subsequently made a part of the Center for Naval Analysis (CNA).

By the late 1940's ADM Forrest P. Sherman, then CNO, asked RADM Ernest E. Herrman, the Superintendent of the Naval Postgraduate School, to establish a new operations-centered curriculum. ADM Sherman reasoned that we should have a nucleus of future line officers who could employ the methods of operations analysis for future combat. The result was the first course of instruction in the world to grant a masters degree in operations research. The first two officers graduated in 1953, followed by four to seven each year year during the rest of that decade. Over the years the NPS faculty has acquired a reputation as one of the three or four preeminent Operations Research Departments in the country. *(We have an Operations Analysis Curriculum taught mainly, but not entirely by the Department of Operations Research. The difference between OA and OR is of interest only to purists.)*

Over the 1960's and '70's the OA curricular emphasis shifted to include more courses in systems analysis and planning, programming and budgeting, which was a natural consequence of the Navy's need to deal on an equal footing with the systems analysts whose thinking so pervaded the Department of Defense decision process in the McNamara years.

More recently, when RADM Allen E. "Boot" Hill, then the Director, Tactical Readiness Division (OP 953) in the



▲ **Writer's cramp is an occupational hazard at NPS. Handwriting legibility is just never the same after what seems an eternity of note-taking.**

▶ **Long sweeping hallways and stairways are as much a part of NPS as text books and computer labs.**

newly created Directorate of Naval Warfare (OP-095), asked the NPS how it could best support CNO's interest in tactical excellence and combat readiness, the answer was easy: the NPS would simply restore its traditional focus on tactical and operational applications. Although the NPS had always viewed operations analysis graduates to be well prepared for either operational tours, force planning decisions, or weapon procurement analysis, it was pleasant to be able to respond to the renewed Navy emphasis with what was always thought of here at the NPS as the wellspring of the curriculum.

The changes the NPS would like to make in the line officer curriculum are moderate and evolutionary. They are illustrated in Figure 1. Four new courses are indicated by shading:

- Introduction to Tactical Analysis
- Weapons Systems and Weapon Effects
- Combat Models and Gaming
- Laboratory in War Gaming

Six other courses we expect to modify extensively are indicated by cross-hatching:

- Basic Operations Analysis
- Radiation Systems (the physics of radar and sonar)
- Mathematical Economics
- Systems Analysis Principles and Methods
- Test and Evaluation
- Campaign Analysis

The electives provide more depth in a field of special student interest. Some examples of electives with a tactical flavor.

- Tactical Design and Analysis
- Application of Search, Detection, and Localization Models to ASW
- Operations Research Problems in Naval Warfare
- Skilled Operator Performance
- Reliability and Weapons System Effectiveness.

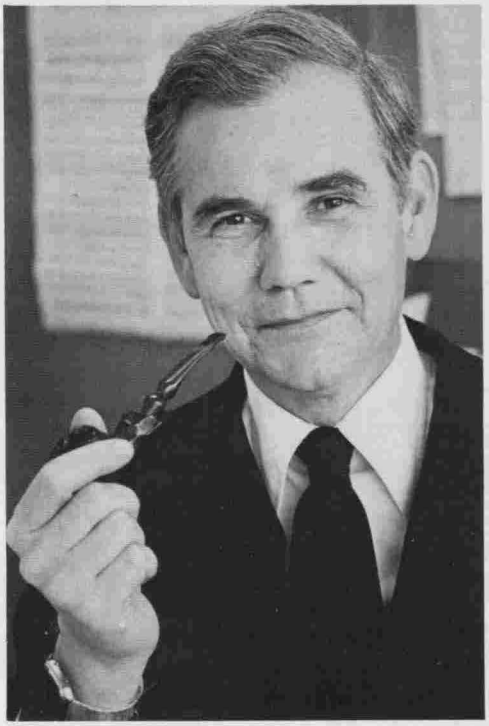
Since the early 1960's a six-week (half-quarter length) "experience" tour has been a popular and essential part of the curriculum. Students apply their fledgling skills at a naval activity that presently does analysis. More often than not they are surprised to find out how much they've already learned during their first year, when it seemed that most of their time was spent learning the fundamentals of probability, calculus, and physics with little more to go on than a casual promise from the faculty that "you're going to need all of this stuff later."

This tour is also a time for searching out a thesis topic, a form of collusion between student and host command, cheerfully endorsed by the OR Department, the object of which is to settle on some research that appeals to the student and for which the host command would otherwise pay good research dollars—say $50,000 or more—to have done.

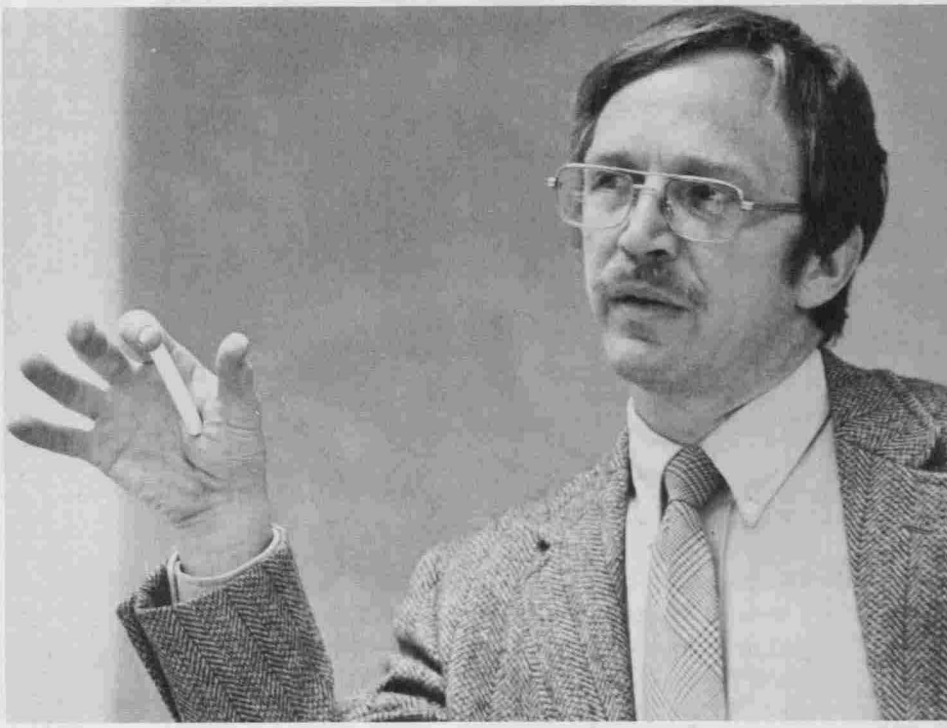
The student thesis is a form of cruel and unusual temptations. You will see in Fig. 1 that the OR Department has begrudgingly yielded up two course blocks of time. In return the students inescapably find themselves committing two or three times as much effort. Try as they may to treat it casually, the thesis becomes an alluring but demanding obsession. When it's all over the typical reaction is: "I never want to go through that again—but I wouldn't have missed it for the world."

◀ Physics professor William B. Zeleny attends to his class work.

▼ CAPT Wayne Hughes—author, professor and curricular officer.



▼ Professor Alan R. Washburn has been teaching at the Naval Postgraduate School in the Operations Research Department since 1970.



Looking only at the surface line officer theses for which I personally have been the student adviser, here are some interesting examples, the utility of which is obvious:

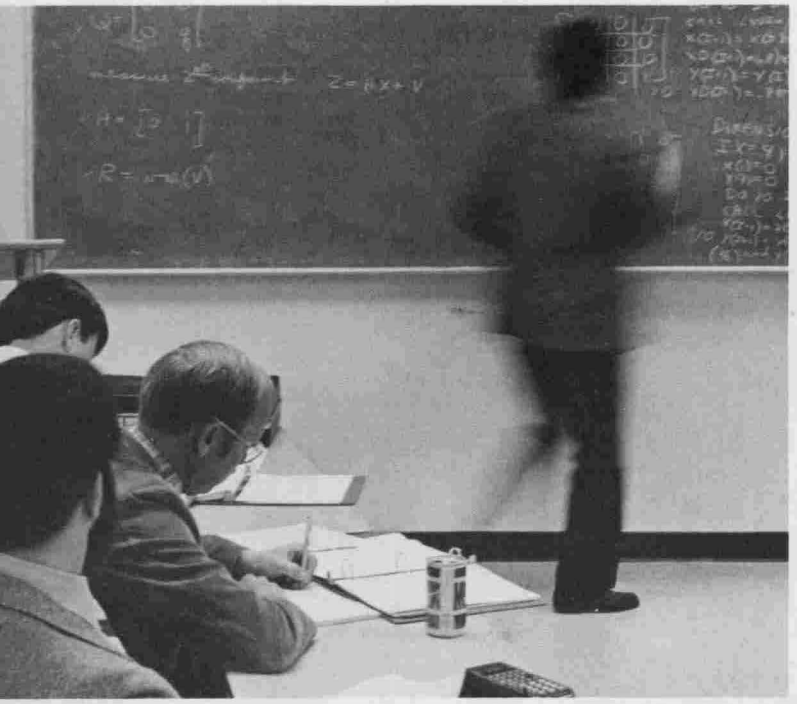
• LCDR Patricia Tracey, *Search Priorities For A Target Probability Area.* Sponsored by COMSECONDFLT Staff, this was a method programmed on a hand-held programmable calculator to assist in Harpoon missile targeting. Pat is now serving in the CNO's Systems Analysis Division (OP-96).

• LCDR Michael Hoert, *An Analysis of Candidate Ship Classes As Potential Naval Reserve Trainers.* Sponsored by the Chief of Naval Reserve, this thesis looked at the pro's and con's of different candidates for the next NRF ships. Mike is on duty in Washington.

• LDCR William "Chip" Boyd. *An Analysis of the Passive Acoustic Detection of Hostile Submarines by Carrier Battle Groups.* Sponsored by OP-96, this thesis applied the Daniel H. Wagner Associates SCREEN model to develop stationing procedures for surface, submarine, and ASW aircraft protection of an on-station, two-carrier battle group. Chip is now XO of USS *Thomas C. Hart* (FF 1092). *(LCDR Tracey and LCDR Boyd were each bestowed the CNO Award for Excellence in Operations Research in their graduating class.)*

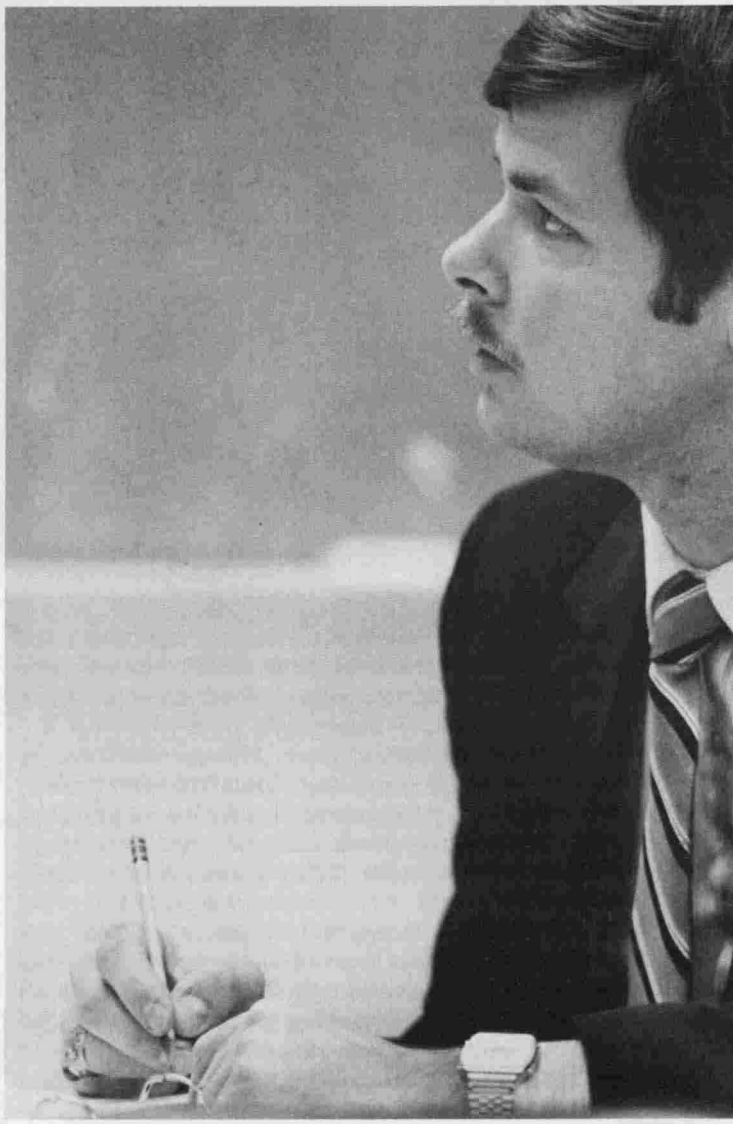
I do not intend to elaborate on all the new courses but a few observations are in order. The *Weapons Systems* course will devote a good bit of time to nuclear weapons. The emphasis will be on effects and tactical employment. The two courses in *War Gaming* are planned to exploit a new war gaming laboratory here that became operational for classified gaming last January. I don't mean to imply that the faculty now puts more stock in gaming than is justified. Quite the opposite: a major purpose will be to expose the students to this tool so that they may contrast their hands-on experience with the pro's and con's of other forms of battle analysis.

A more detailed examination of the new course titled *Introduction to Tactical Analysis* will be of particular interest to fleet sailors. Since it is designed to survey all aspects of tactical analysis, it is a series of vignettes selectively lifted from the entire curriculum, specifically, those portions of the curriculum that deal with fleet problems. As you read the course description in the next paragraph, you will note the contrast between what we teach at NPS and what is taught at either the Naval War College or in the Fleet Tactical Schools, under COMTRALANT and COMTRAPAC. The difference is in the focus: the NPS aims for *timelessness* and the latter schools aim for *timeliness.* NPS endeavors to teach the analytical principles that will endure. They focus on today's forces, threat and doctrine in order to be ready to fight tomorrow morning. They are preparing students for the billet they now fill or will hold tomorrow. NPS wants our graduates, who are LT's and LCDR's, to have the enduring skills and the analytical *frame of mind* that will serve them in good stead throughout an entire career, perhaps at once on a fleet staff, later in command of a ship, and eventually in command of a battle group. We are even so ambitious as to believe a CNO some day will be a graduate, or ought to be. Thus, some of our graduates might naturally be found on the War College faculty, or on the staff of CAPT Stu Landersman's or CAPT Don Cannell's Com-



◀ Professor Alan Washburn moves to express his thoughts on the board.

▼ LT Steven Burich glances from his notes to the chalk board. The lieutenant came to NPS from NAS Jacksonville where he flew P-3's. The combat models and weapons effectiveness class is part of his course of study in anti-submarine warfare. LT Burich said that he hopes to acquire "a better appreciation of the technical and environmental aspects of ASW" through his class.



mand Tactical Training Courses *(See "RADM "Boot" Hill Talks Tactical Training,"* Surface Warfare *Magazine, Oct. 1980; and "A New Tack for Tacticians",* Surface Warfare *Magazine, Nov. 1980),* thus making them contributors to those already fine courses.

Now, then, here is the course content of the *Introduction to Tactical Analysis.* All of the following aims at fulfilling one objective: to introduce students to tactical analysis concepts, tools, and material they will receive in greater detail later in the curriculum. Through the following means, the course emphasizes ways to (1) determine, and (2) improve on the readiness and the performance of weapons *systems,* singly and in combination.

• *Measuring Combat Capabilities of Weapon Systems:* detection measurement; weapon effectiveness; mobility and maneuver; logistics, reliability, and maintainability; human factors and "vigilance", training, leadership, and behavior in combat; and environmental effects.

• *Predicting Combat Performance*—introducing the opponent: elementary principles of search and screening; game and decision theory concepts (these are terms for narrowly defined analytical processes); one-on-one engagement analyses; and theater nuclear weapons.

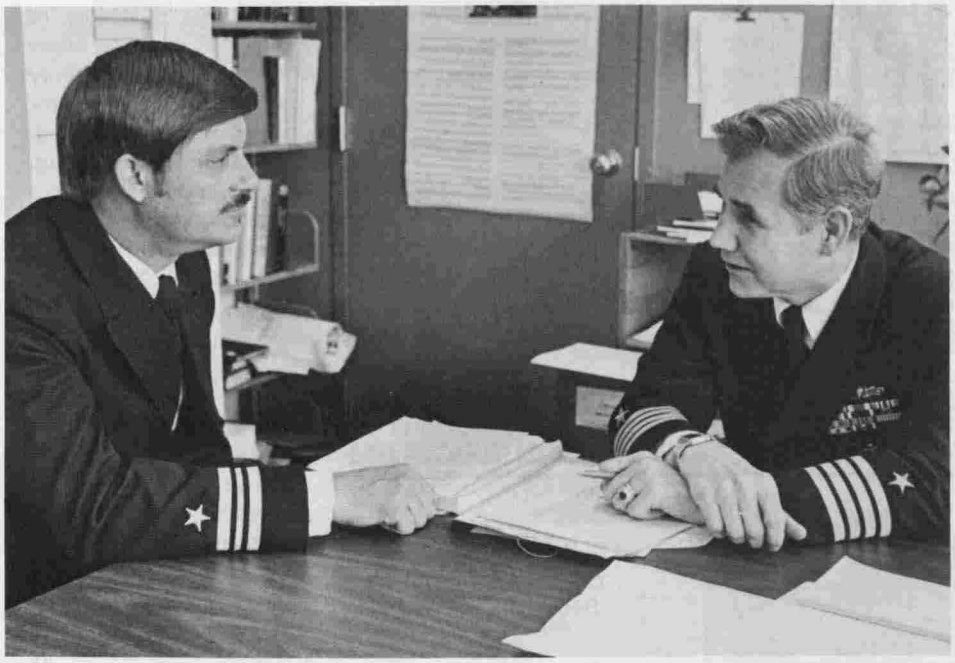
• *Methods of Tactical Analysis*—directing multiple forces in battle: the Composite Warfare commander TACNOTE (in addition, each student reports on a TACMEMO of his choice, emphasizing the analytical process that undergirds it); descriptive combat models (such as Lanchester equations and Markov processes); and descriptive and prescriptive combat models, using AAW and ASW illustrations.

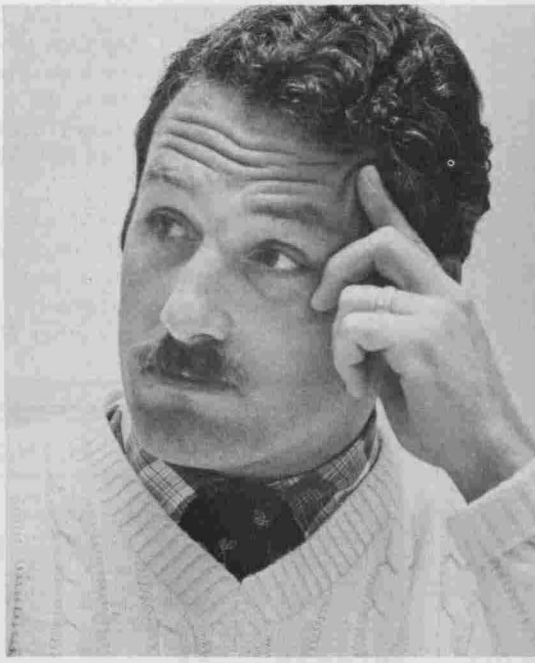
• *Organization for Fleet Analysis:* the U.S. Navy TAC D&E structure, process and publications; the exercise design process.

Planned but not yet developed are lessons on cover and deception; World War II and Vietnam field experience; OT&E and the weapons system testing process; and the Soviet use of operations analysis.

Regarding the latter, the Soviets have published extensively on operations analysis, and since Marxist-Leninist doctrine subscribes to the scientific approach (ironic as this may strike you) if it is "ideologically correct," they seem to be busily incorporating analytical (read "scientific") methods directly into their doctrine.

In order to give a better appreciation of the threat and of Soviet Naval doctrine and C^3 structure we invited CAPT Landersman to bring a part of his Tactical Training Group Staff up from San Diego to give a five-day abbreviated course. In addition to the threat size, they will





▲ CAPT Wayne Hughes talks with LCDR Lee Dick about a possible thesis topic.

▶▲ LCDR Maurice McNeil, LAMPS pilot and student, was quick to point out a simple error, "Professor, I've learned to catch mistakes like that, I make a lot of them." LCDR McNeil will report to HSL-33 in San Diego upon his graduation in October. The commander spent his second tour as an instructor at SWOSCOLCOM in the Department Heads curriculum.

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cover current U.S. Navy capabilities, C^3, and current tactics. This is an experiment. If it is as successful as we expect, with the generous acquiescence of the TACTRAGRU and COMTRAPAC, we will institutionalize the event on an annual or semi-annual basis.

The course examinations are designed to test the students' broader ability to think, write, and solve problems; not merely his ability to manipulate mathematics. I have included some sample exam questions to illustrate.

Continued implementation of the curriculum changes could be threatened if teaching resources cannot be found. The auspicious changes that I've portended depend crucially on one major contingency. RADM John J. Ekelund, the Superintendent, has committed the NPS to the program in principle. But, he says, "To make these changes work—to bring it all together—additional resources are required. We have a premier faculty here, but to teach *tactical* analysis, we have got to supplement them with tacticians with warfare skills for curriculum and course development and execution.

"I mean," he stresses, "naval officers with fleet experience, and they must be good. They must have the right blend of saltwater and an operations analysis background. Without at least two quality officers with these skills—and I would have preferred three—we are going to develop slowly and the final product will be less than what I want, less than what's achievable, and less than what the fleet needs."

Toward that end, OP-01 has established a captain billet for the Chair of Tactical Analysis. I personally believe the first incumbent must create a standard of excellence comparable to the military chairs at M.I.T. or Princeton. However, the chair holder by himself is not enough.

There is another reason why a sprinkling of additional fleet officers must, in the end, seed the faculty of the Navy's own extraordinary graduate university. I have focused attention on the operations research curriculum, but there are other recent changes that bode well for the fleet. Since 1973 four new curricula leading to Master's Degrees have been started and are specifically aimed at improved fleet readiness. They are:

- Antisubmarine Warfare (first graduates 1975)
- Electronic Warfare (first graduates 1979)
- Command, Control, and Communications (first graduates 1979)—sponsored by the Assistant Secretary of Defense (C3I), this is an all-service curriculum
- Air-Ocean Tactical Environment Support (established 1980)

These curricula were conceived for graduate line officers who will be able to use their education in the fleet. Each curriculum is a blend of operations analysis, science, and engineering. Thus, graduates will be able to attack tactical, scientific, and technological problems. From a slightly different perspective, these curricula adapt the same philosophy that those pioneering scientists who invented radar brought with them to the Battle of Britain: science, technology, and tactics all converge in modern combat, and the best solutions emerge when the three are treated as inseparable.

I would be remiss if I did not stress that the Naval Postgraduate School curricula all respond to sponsor requirements. When OP-953 prompted the changes that I have described, they were made in response to specific objectives. However, the operations analysis curriculum has long been sponsored by the Systems Analysis Division (OP-96), and his concurrence was also necessary. It

is gratifying to record RADM Leland S. Kollmorgen's (Director, Systems Analysis Division, OP-96) reaction when he was briefed here during the annual curriculum review. Warmly endorsing the school's evolutionary approach, his straightforward "Get started" was strongly encouraging. OP-095, whose role is now as curriculum "consultant", also agreed.

In closing, a word about what operations analysts do. The notion is prevalent that they do operations analysis when they occupy their subspecialty billets. That is, of course, true. But additionally, operations analysts, as much or more than any other NPS graduates, use their education wherever they serve. Analysis is a way of thinking. Optimization is always desirable: having some tools with which to optimize is the rub. If I had my way I would discard the concept of "subspecialty billets" for operations analysts if for no other reason then to emphasize that a good analyst is always using his education.

In my opinion, operations analysis is the finest curriculum in the world for seagoing line officers who covet the responsibilities of command, and would if they could, think tactics and prepare themselves for combat all day and all night.

Well maybe not *all* night.

Figure 1

PLANNED OPERATIONS ANALYSIS CURRICULUM

— First Year —			
Introductory Computing	Introduction to Tactical Analysis	Methods of Operations Research	Computer System Simulation
Basic Operations Analysis			
Linear Algebra	Linear Programming	Stochastic Models I	Mathematical Economics
Calculus	Multivariable Calculus	Radiation (Radar and Sonar) Systems	Weapons Systems and Weapon Effects
Probability Theory	Probability and Statistics	Statistics	Search Theory & Detection
— Second Year —			
Combat Models and Gaming	War Gaming Laboratory	Elective+	Campaign (Theater Level) Analysis
Systems Analysis	Non-linear & Dynamic Programming	Stochastic Models II	Elective+
Experience Tour	Human Factors	Elective+	Test and Evaluation
Experience Tour	Analysis of Operational Data	Thesis Research	Thesis Research

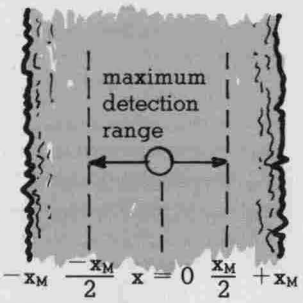
Requests for more information about the Operations Analysis Curriculum and the other tactics-oriented curricula should be directed to the Office of Continuing Education. The appropriate mailing address is Superintendent (Code 500), Naval Postgraduate School, Monterey, CA 93940 (Phone: (AVN) 878-2558). The Continuing Education Office also distributes self-study courses from the first quarter of these curricula which may be taken for credit at the officer's current duty station. Enrollment forms and a description of the off-campus self-study program are available in the Catalogue of Self-Study Courses which is mailed annually to all ships and stations and Navy Campus for Achievements Offices. Requests for copies of the self-study catalog and the NPS catalog should be addressed to the Office of Continuing Education at the above address or phone number.

Introduction to Tactical Analysis (OA2601)

Second Exam
26 Feb 1980

1. A sonar located in the middle of a channel has a 50% probability of detecting submarines that pass at any distance from it up to half the distance to either side of the channel, and no probability of detecting submarines beyond.

Assume that submarines are only 1/2 as likely to take a path $\frac{-x_M}{2} \le x \le \frac{x_M}{2}$ as they are to follow a path x beyond the sonar's detection range. (This is not the same as saying half the submarines are subject to detection and half are not).



a. Sketch the lateral range curve $\bar{p}(x)$ for the sonar as a function of x.
b. Write the mathematical expression for the lateral range curve.
c. Sketch the probability density function f(x) of submarines as a function of x.
d. Write the mathematical expression for the submarine density.
e. What fraction of submarines is expected to be detected under the circumstances?

2. If three sensors have the following probabilities of detecting a target at a point (x,y):

Sensor	p(x,y)
A	.20
B	.30
C	.40

a. What is the probability that at least one will detect the target at (x,y) if each detects independently of the other?
b. What is the joint probability of detection if there is perfect correlation between sensors?
c. What is the probability that a cross fix may be obtained from at least two sensors, assuming each detects independently?

3. Telewigits are believed to fail at a constant rate. A test of 200 telewigits had 100 failures in 500 hours. How many altogether can be expected to have survived after 1000 additional hours?

4. If the payoffs for actions A1, A2, and A3 are as shown, for what range of values of $0 \le P \le 1$ would you prefer each action?

	States of Nature	
	S1	S2
	P	1-P
Actions A1	$20	−$2
A2	−$4	$60
A3	$15	−$3

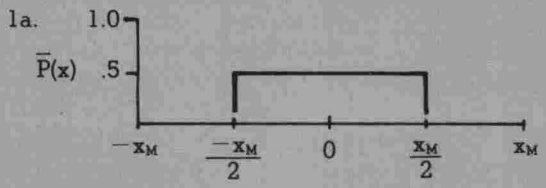
5. Which (one or more) of the following statements regarding Game Theory is true?

a. Game Theory is a conservative approach to decision making.
b. Game Theory invokes a strategy suitable for the superior force.
c. It is not always necessary for the value of the game to be positive to win if there is a saddle point and you play the optimal strategy.
d. A mixed strategy for both players will be the game solution when the values of the minimax and maximin strategies are different.

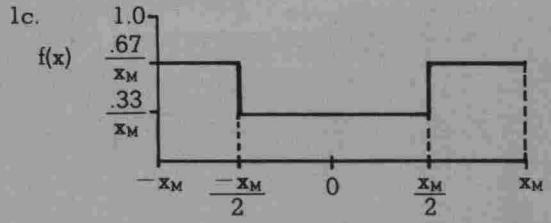
6. Blue and Red with 250 and 100 combat units respectively met in battle in which the Lanchester square law applied. Red unit effectiveness was 4 times as great as Blue's.

a. After 30% of the Red units were casualties, the Red force broke and ran from the battlefield. While Blue was reconstituting and preparing to pursue Red, they were astonished to hear a Red broadcast claiming an impressive victory. What was the basis of the Red claim?
b. In a fight to the finish, which side would win?
c. Show the Red and Blue casualties in the two cases above.

Answers to Exam Questions

1a. 

1b. $\bar{P}(x) = .5$ if $x \le \left|\frac{x_M}{2}\right|$
$= 0$ if $x > \left|\frac{x_M}{2}\right|$

1c. 

1d. $f(x) = \frac{2}{3x_M}$ if $-x_M \le x < \frac{-x_M}{2}$
or $\frac{x_M}{2} < x \le x_M$
$= \frac{1}{3x_M}$ if $\frac{-x_M}{2} \le x \le \frac{x_M}{2}$

1e. One-sixth

2a. .66 b. .4 c. .21

3. Twenty-five

4. Choose strategy A1 if $P > .721$
Choose strategy A2 if $P < .721$
Indifference between A1 and A2 when $P = .721$
Never choose strategy A3

5a. True b. True c. False d. True

6a. When 30% of Red were casualties, Red had lost only 2/3 as many units as Blue
b. But Blue will win a fight to the finish and have 150 surviving units
c. When Red has lost 30%, Red casualties = 30
Blue casualties = 45
In a fight to the finish Red casualties = 100
Blue casualties = 100